CLAIMS

What is claimed is:

1. A method for producing a lithographically printed image having a reduced critical dimension, the method comprising the steps of:

(a) providing a semiconductor substrate optionally having at least a hardmask defined thereon;

(b) providing an underlayer on said hardmask wherein said underlayer is substantially free of any element that forms a non-volatile oxide;

(c) providing a PR layer on said underlayer, wherein said photoresist comprises a material capable of forming a non-volatile, etch-resistant oxide;

(d) imagewise exposing said PR layer to radiation forming an image in said PR;

(e) transferring said image into said underlayer; and

(f) performing a controlled overetch of said underlayer.

plasma etching said underlayer, wherein the reactive species of said plasma comprises oxygen; and

performing a controlled lateral thinning of said underlayer.

2. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said underlayer comprises less than 9% silicon.

3. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said underlayer comprises a tuned polymer.

4. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said underlayer is substantially free of any element that forms a non-volatile oxide wherein said element is selected from the group consisting of silicon, boron, phosphorous, germanium, and aluminum.

5. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said photoresist comprises an element capable of forming a non-volatile, etch-resistant oxide selected from the group consisting of silicon, boron, phosphorous, germanium, and.

6. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein the reactive species of said plasma comprises an element selected from the group consisting of oxygen, hydrogen, fluorine, and chlorine.

7. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said underlayer comprises a tuned polymer comprising carbon, hydrogen, and oxygen.

8. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said underlayer comprises an antireflective coating.

9. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said PR comprises a radiation-sensitive acid generator.

10. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said photoresist comprises a polymer having acid-cleavable moieties bound thereto.

11. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said photoresist comprises a polymer formed by polymerizing one or more monomers selected from the group consisting of acrylate, methacrylate, hydroxystyrene optionally substituted with C_{1-6}-alkyl, C_{5-20} cyclic olefin

monomers, and combinations thereof, the polymer having acid-cleavable moieties bound thereto, wherein all such moieties are silylethoxy groups optionally substituted on the ethoxy portion thereof with C_{1-6}-alkyl, phenyl, or benzyl.

12. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said radiation is selected from the group consisting of electromagnetic radiation, 157-365 nm ultraviolet radiation, euv, electron beam radiation, and hard and soft x-ray radiation.

13. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said radiation comprises ultraviolet radiation or extreme ultraviolet radiation.

14. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said ultraviolet radiation comprises substantially monochromatic radiation having a wavelength of from about 157 nm to about 365 nm.

15. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said ultraviolet radiation comprises substantially monochromatic radiation having a wavelength selected from the group consisting of 157, 193, 248, 254, and 365 nm.

16. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said radiation comprises x-ray radiation.

17. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said photoresist comprises a stable, etch-resistant, non-

volatile oxide-forming material selected from the group consisting of silicon, phosphorous, germanium, aluminum, and boron.

18. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said plasma comprises a reactive species selected from the group consisting of oxygen, hydrogen, fluorine, and chlorine.

19. A method for reducing the critical dimension of a lithographically printed feature, according to claim 1, wherein said tuned polymer comprises an organic polymer selected from the group consisting of phenolic polymers, novolacs, epoxies, and diamond-like carbon.

20. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 1, wherein transferring said image comprises plasma reactive-ion etching.

21. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 18, wherein said reactive species comprise neutrals and ions.

22. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 1, wherein performing controlled overetch comprises controlling the etch rate.

23. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 22, wherein controlling said etch rate comprises adding a non-reactive diluent gas to said plasma.

24. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 23, wherein said non-reactive diluent gas comprises nitrogen and noble gasses.

25. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 22, wherein controlling said etch rate comprises regulating process parameters.

26. A method for producing a lithographically printed image having a reduced critical dimension, according to claim 22, wherein said process parameters consist of variables selected from the group consisting of the duration of etch, the rf power, operating pressure, gas flowrates, backside He pressure, electrode temperature, and wall temperature.

27. The reduced critical dimension bilayer resist image comprising:

a semiconductor substrate;

an organic layer provided on said substrate; and a photoresist layer provided on said organic layer, wherein said photoresist layer has a first image developed therein, and wherein said organic layer has a second image, of reduced critical dimension and congruent with said first image, developed therein.

28. A method of using a reduced critical dimension bilayer resist image comprising the steps of:

(a) providing a substrate;

(b) forming a reduced critical dimension bilayer resist image on said substrate;

(c) transferring said image into said substrate forming a circuit image; and

(d) forming circuit element materials in said circuit image.

29. A method of using the reduced critical dimension bilayer resist image, according to claim 25 wherein said circuit element materials comprise materials selected from the group consisting of dielectric, conductor, semiconductor, and doped semiconductor materials.

30. The semiconductor device fabricated using a reduced critical dimension bilayer resist image.